RafandhaPress

Bulletin of Educational Management and Innovation
https://journal.rafandhapress.com/BEMI/article/view/185
E-ISSN: 2986-8688 | https://journal.rafandhapress.com/BEMI

RESEARCH ARTICLE

Managing AI-assisted scientific writing training for teachers: Evidence from Tapanuli Utara, Indonesia

Humiras Betty Marlina Sihombing[1]*, Fenny Yutika Seli[1], Pribawa E Pantas[2]

[1] Universitas Media Nusantara Citra, Jl. Panjang Blok A8, Jl. Green Garden Pintu Utara Prov. D.K.I, RT.1/RW.3, North Kedoya, Kebonjeruk, West Jakarta City, Jakarta 11520, Indonesia

[2] Universiti Islam Selangor, Bandar Seri Putra, 43000 Kajang, Selangor Darul Ehsan, Malaysia

*Correspondence: ✉ humiras.betty@mncu.ac.id

ABSTRACT

Background: The increasing use of artificial intelligence (AI) is reshaping teacher professional development, including scientific writing and other forms of academic work. However, access to AI-enabled professional learning and the capacity to integrate such technologies into training are not necessarily uniform, particularly in resource-constrained educational contexts.

Purpose: This study examines AI-assisted scientific writing training for junior secondary school teachers in Tapanuli Utara, Indonesia, focusing on three dimensions: training management, AI technology integration, and perceived training effectiveness.

Method: A mixed-methods approach was employed involving 30 junior secondary school teachers from Tapanuli Utara. Quantitative data were collected using a five-point Likert-scale questionnaire measuring training management, AI technology integration, and perceived training effectiveness. Descriptive statistics and Pearson correlation analysis were used to examine the distribution and associations among the variables. Open-ended responses were also collected to provide contextual information regarding participants' experiences with the training. The open-ended responses were reviewed descriptively as supplementary contextual evidence rather than subjected to a separate formal thematic analysis.

Findings: The results showed that perceived training effectiveness received the highest mean score (M = 4.01), followed by AI technology integration (M = 3.88) and training management (M = 3.57). Training management was moderately positively associated with AI technology integration (r = 0.37), while it was moderately negatively associated with perceived training effectiveness (r = −0.44). AI technology integration showed a weak negative association with perceived training effectiveness (r = −0.22). Taken together, these findings do not support a simple linear assumption that more favorable training management and greater AI integration necessarily correspond to higher perceived training effectiveness. Rather, they indicate a more complex relationship among training organization, technology integration, and participants' perceptions of learning effectiveness.

Implication: These findings suggest that AI-assisted teacher training should balance clear organization and technological support with sufficient flexibility to accommodate differences in participants' digital readiness and learning needs.

Article History

Received: 16 August 2026
Revised: 08 October 2026
Accepted: 24 October 2026
Published: 30 October 2026

Keyword

Artificial intelligence; scientific writing; teacher professional development; training management.

© 2026, Authors

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License

How to cite:
Sihombing, H. B. M., Seli, F. Y., & Pantas, P. E. (2026). Managing AI-assisted scientific writing training for teachers: Evidence from Tapanuli Utara, Indonesia. *Bulletin of Educational Management and Innovation*, *4*(2). 606-624. https://doi.org/10.56587/bemi.v4i2.185

INTRODUCTION

The rapid development of artificial intelligence (AI) is changing the nature of professional work in education. For teachers, this transformation extends beyond classroom instruction to include professional learning, information management, content development, and academic writing. Scientific writing is increasingly relevant to teachers' professional development because teachers are expected not only to implement instructional practices but also to document, evaluate, and communicate professional knowledge. Recent developments in generative AI have further expanded the possibilities for academic writing by supporting activities such as ideation, drafting, revision, and dissemination, while simultaneously raising questions about authorship, ownership, and critical engagement with AI-generated content (Ros & Samuel, 2025; Sanz-Tejeda et al., 2026). In the Indonesian context, these expectations have become increasingly visible alongside broader reforms that emphasize teacher professionalism, reflective practice, and evidence-based educational improvement. The original manuscript identifies scientific writing as an increasingly important component of teachers' professional development, while also noting persistent limitations in teachers' access to training, academic-writing confidence, and technology integration. Recent studies similarly show that generative AI is becoming embedded in teachers' professional work while creating new demands for technological readiness, AI competence, and targeted professional development (Cheah et al., 2025; Moorhouse, 2024; Ng et al., 2025; Yue et al., 2024).

AI-assisted writing tools potentially address some of these challenges by supporting activities such as idea generation, language refinement, drafting, revision, and feedback (Ahmed, 2025). Evidence from writing-focused research also indicates that AI tools can influence the content and organization of written work, while AI-generated feedback has increasingly become an area of systematic educational research (Marzuki et al., 2023; Youn & Salam, 2025). Recent research has also begun to examine how generative AI tools can affect not only writing performance but also motivation and emotional experiences associated with writing. For example, Wang et al. (2025) examined the roles of ChatGPT and Grammarly in relation to emotion regulation, motivation, psychological well-being, and academic writing, highlighting the broader educational consequences of AI-assisted writing rather than treating AI solely as a technical writing tool.

Nevertheless, access to AI tools does not automatically translate into effective professional learning. The educational value of AI therefore depends not only on

technological availability but also on users' digital readiness, perceived usefulness, and the support available for meaningful adoption (Chandra et al., 2025). Evidence from Indonesian teachers indicates that digital readiness and perceived usefulness are important in shaping intentions to use AI in schools (Harsanti et al., 2025). Teachers require sufficient digital readiness, perceived usefulness, institutional support, and opportunities to understand how AI can be used appropriately within their professional activities. Recent evidence from Indonesian junior secondary school teachers similarly indicates that technological readiness is an important component of teachers' readiness to adopt AI, reinforcing the importance of training and professional development (Zaki & Ulya, 2025). This is particularly important because excessive reliance on AI may create educational and ethical risks when users delegate cognitive or evaluative processes to automated systems rather than using AI as a supportive resource (Abubakar et al., 2025). Recent evidence from Indonesian teachers indicates that digital readiness and perceived usefulness are important in shaping teachers' intention to use AI, while training, support, and resource access also influence the relationship between digital leadership and AI adoption.

The question of how AI is incorporated into professional development is therefore as important as whether AI is available. This issue is particularly relevant in AI-enabled professional learning because teachers may require structured guidance while also needing sufficient autonomy to explore tools according to their individual competence and professional needs. Narayan and Vanderburg (2025) similarly emphasize learner-centred and self-determined learning in the context of generative AI, highlighting learner voice, criticality, authenticity, and partnership. Training management therefore encompasses not only the organization of objectives, activities, facilitation, flexibility, and feedback, but also the extent to which these elements allow participants to adapt learning to their professional needs. A well-organized training program may provide direction and reduce uncertainty; however, excessive standardization may limit opportunities for participants to explore technologies according to their different levels of competence and experience. This issue becomes particularly relevant in AI-assisted writing because participants may differ considerably in their prior digital experience, confidence, writing ability, and familiarity with AI tools.

The relevance of learner autonomy is also emphasized in recent discussions of AI and heutagogy. Narayan and Vanderburg (2025), for example, argue for learner-centred and self-determined approaches in the context of generative AI, emphasizing learner voice, criticality, authenticity, and partnership in educational processes. This perspective suggests that AI-supported professional development should not be designed solely around the delivery of predetermined content. Instead, teachers may require opportunities to

experiment, receive feedback, and connect AI-supported activities with their own professional objectives.

These issues are particularly important in geographically and digitally diverse contexts. The present study focuses on junior secondary school teachers in Tapanuli Utara, North Sumatra, where the manuscript identifies differences in digital infrastructure and internet access as contextual challenges for professional development. Similar teacher-training initiatives in Indonesia have shown that AI integration requires structured practice and continued support rather than one-time exposure to the technology (Fauziah et al., 2024). Rather than treating this setting merely as a geographical location, the study considers it a context in which the relationship between training organization, technology integration, and perceived effectiveness can be examined.

Previous studies have examined AI-assisted writing, AI-supported feedback, teacher AI adoption, and self-determined learning from different perspectives (Harsanti et al., 2025; Marzuki et al., 2023; Narayan & Vanderburg, 2025; Youn & Salam, 2025). However, empirical evidence remains limited regarding how training management, AI technology integration, and perceived training effectiveness are associated within AI-assisted scientific writing training for school teachers, particularly in a context outside major urban educational centres. This study addresses this gap by examining these three dimensions simultaneously.

Accordingly, this study aims to analyze the management of AI-assisted scientific writing training for junior secondary school teachers in Tapanuli Utara. Specifically, it examines: (1) teachers' perceptions of training management; (2) the extent to which AI technology is integrated into the training; (3) perceived training effectiveness; and (4) the associations among these three dimensions. The study contributes empirical evidence to discussions of AI-supported teacher professional development by highlighting the possibility that technology integration, training management, and perceived effectiveness may not necessarily move in the same direction.

METHODS

Research Design

This study employed a convergent (concurrent) mixed-methods design with a quantitatively dominant strand. Quantitative questionnaire data and qualitative open-ended responses were collected within the same phase. The quantitative component was used to describe participants' perceptions of training management, AI technology integration, and perceived training effectiveness and to examine the associations among these variables, while the open-ended responses were used as supplementary contextual information. This design was selected because the study sought to examine numerical patterns while retaining participants' descriptions of their experiences within the same training context.

The design is therefore neither exploratory sequential nor explanatory sequential because no separate qualitative-to-quantitative or quantitative-to-qualitative sequence was undertaken. Instead, the qualitative responses were embedded in the same data-collection phase and were intended to contextualize the quantitative findings.

Research Context and Participants

The study was conducted in Tapanuli Utara Regency, North Sumatra, Indonesia. The location was selected because the implementation of AI-supported professional development is not necessarily uniform in areas where digital infrastructure and internet access remain variable. This contextual condition is particularly relevant when examining technology-supported teacher development.

The participants were 30 junior secondary school teachers from public and private schools in Tapanuli Utara. Participants were selected based on predetermined criteria, including more than five years of teaching experience, willingness to participate throughout the research process, and basic experience with digital devices and technologies. These criteria were intended to ensure that participants possessed sufficient professional experience and basic digital competence relevant to the objectives of the study The sample reflected the available cohort of eligible teachers who participated in the training and met these criteria. It should therefore be understood as a bounded, context-specific purposive sample rather than a statistically representative sample. Following recommendations for transparent sample-size justification, the relatively small sample is acknowledged when interpreting the correlational findings and their generalizability (Lakens, 2022).

Research Variables and Instrument

Three principal variables were examined: (1) Training Management, (2) AI Technology Integration, (3) Perceived Training Effectiveness.

The variables were operationalized through indicators (Table 1) derived from the theoretical references identified in the original manuscript. Training-management indicators were additionally situated in recent teacher professional-development literature (Sims & Fletcher-Wood, 2021), while indicators of AI integration and readiness were supported by research on teachers' AI preparedness, adoption, and competence (Hazzan-Bishara et al., 2025; Moorhouse, 2024; Shi, 2025; Yue et al., 2024). Perceived training effectiveness was aligned with literature on AI-assisted writing and AI-supported professional learning (Marzuki et al., 2023; Nurmasitah et al., 2025; Zhang & Wang, 2025).

Table 1.

Operationalization of Research Variables

Variable	Indicators	Operational Focus

Training Management	Clarity of training objectives; training organization; facilitation and guidance; implementation flexibility; evaluation and feedback	How clearly and systematically the training was organized and how participants were supported during the training
AI Technology Integration	Use of AI-based writing tools; integration of digital platforms; accessibility of digital learning tools; perceived usefulness of AI tools; readiness to use digital technology	The extent to which AI and digital technologies were incorporated into scientific writing activities
Perceived Training Effectiveness	Increased writing motivation; increased writing confidence; improved scientific writing skills; satisfaction with training; application of training outcomes	Participants' perceptions of the benefits and applicability of the training

The indicators were developed from the literature on AI-assisted writing, AI-supported feedback, teacher AI adoption, and technology-supported professional learning (Harsanti et al., 2025; Marzuki et al., 2023; Ros & Samuel, 2025; Youn & Salam, 2025). The questionnaire used a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). It also included open-ended questions to capture participants' experiences, perceived barriers, and responses to the use of AI in scientific writing. Recent studies also emphasize the importance of teacher preparedness, professional-development needs, responsible AI use, and contextual support when evaluating AI-related professional learning (Chen et al., 2025; Huynh et al., 2025; Somabut et al., 2025).

Data Collection

Quantitative data were collected through the structured Likert-scale questionnaire. The questionnaire measured participants' perceptions of the three research variables. Qualitative information was obtained through open-ended responses concerning participants' experiences and views regarding the training and use of AI for scientific writing.

The study also reports that participants provided consent to participate and to the use of their research data. In addition, formal permission was obtained from the Government of Tapanuli Utara through the local Education Office.

Data Analysis

Quantitative data were analyzed using descriptive statistics and Pearson's product-moment correlation. Descriptive statistics were used to identify the central tendency of each research variable, whereas Pearson's correlation was used to examine the direction and strength of associations between training management, AI technology integration, and perceived training effectiveness.

Given the correlational objective, three non-directional hypotheses were examined: H1, training management is associated with AI technology integration; H2, training

management is associated with perceived training effectiveness; and H3, AI technology integration is associated with perceived training effectiveness. The direction of the associations was not specified a priori.

The open-ended responses were treated as supplementary contextual material rather than as a stand-alone qualitative dataset. They were reviewed descriptively to assist interpretation of the quantitative patterns and were not subjected to a separate formal thematic analysis. This approach was consistent with their supporting role within the quantitatively dominant mixed-methods design.

RESULT AND DISCUSSION

Training management obtained the lowest mean score among the three dimensions (M = 3.57) (see Table 2). This indicates that participants evaluated the organization and management of the training less favorably than AI technology integration and perceived training effectiveness.

Table 2.

Descriptive Statistics of the Research Variables

Research Variable	Mean (M)	Relative Position
Training Management	3.57	Lowest
AI Technology Integration	3.88	Intermediate
Perceived Training Effectiveness	4.01	Highest

AI technology integration obtained a mean score of M = 3.88, placing it between training management and perceived training effectiveness. Perceived training effectiveness obtained the highest mean score (M = 4.01), indicating that participants evaluated the benefits and applicability of the training more favorably than the other two dimensions. The pattern is noteworthy because participants perceived the effectiveness of the training more positively than its management. In other words, a favorable assessment of training outcomes was not accompanied by an equally favorable assessment of how the training was organized and managed. This distinction provides an important basis for interpreting the correlation findings.

Associations among Training Management, AI Technology Integration, and Perceived Training Effectiveness

Pearson's correlation analysis (table 3) revealed three different patterns of association among the variables.

Table 3.

Pearson Correlation Matrix

Variable	AI Technology Integration	Perceived Training Effectiveness
Training Management	r = 0.37	r = −0.44
AI Technology Integration	—	r = −0.22

The relationship between training management and AI technology integration was moderately positive (r = 0.37). This suggests that more favorable perceptions of training management tended to be associated with more favorable perceptions of AI integration.

In contrast, training management showed a moderate negative association with perceived training effectiveness (r = −0.44). This was the most notable relationship identified in the analysis because it ran in the opposite direction to what might conventionally be expected from a well-managed training program.

Finally, AI technology integration showed a weak negative association with perceived training effectiveness (r = −0.22). This indicates that higher perceptions of AI integration were not accompanied by higher perceived training effectiveness in this sample.

These correlation coefficients should be interpreted as associations rather than causal effects. In particular, the negative coefficient between training management and effectiveness does not establish that training management reduced effectiveness.

Integrated Interpretation of the Main Findings

Taken together, the descriptive and correlation analyses reveal a non-linear pattern among training management, AI technology integration, and perceived training effectiveness. Training management was positively associated with AI technology integration but negatively associated with perceived training effectiveness, while AI technology integration showed a weak negative association with perceived training effectiveness. These findings indicate that the relationship among the three dimensions cannot be adequately explained through a simple assumption that better training management and greater AI integration necessarily lead to higher perceived effectiveness.

Table 4.
Integrated Interpretation of the Main Findings

Finding	Statistical Evidence	Interpretation

Training management and AI integration	r = 0.37	Better perceptions of training management tended to coincide with more favorable perceptions of AI integration
Training management and effectiveness	r = −0.44	More favorable perceptions of management did not coincide with higher perceived effectiveness
AI integration and effectiveness	r = −0.22	Greater perceived AI integration did not correspond to higher perceived effectiveness
Overall pattern	—	The relationships do not support a simple linear assumption that better management and greater AI integration automatically produce higher perceived effectiveness

Taken together, the descriptive and correlation analyses reveal a non-linear pattern in the relationships among training management, AI technology integration, and perceived training effectiveness (table 4). Although perceived training effectiveness received the highest mean score (M = 4.01), training management showed only a moderate positive association with AI technology integration (r = 0.37) and a moderate negative association with perceived training effectiveness (r = −0.44). AI technology integration also showed a weak negative association with perceived training effectiveness (r = −0.22). These findings indicate that the relationships among the three dimensions cannot be adequately explained by a simple linear assumption in which stronger training management and greater AI integration necessarily lead to higher perceived training effectiveness. Instead, the results point to a more complex pattern in which the organization of training and the integration of AI may interact with participants' learning experiences and contextual needs. Further interpretation of these relationships is presented in the Discussion section.

DISCUSSION

High Perceived Effectiveness Despite Lower Perceptions of Training Management

The first important finding is the discrepancy between perceived training effectiveness and training management. Participants gave the highest mean score to training effectiveness (M = 4.01), whereas training management received the lowest score (M = 3.57).

This pattern suggests that participants could perceive substantial value in the training even when they were less positive about the way the training was organized. The distinction is theoretically important because training effectiveness should not necessarily be treated as a direct reflection of administrative or organizational quality. Participants may value the practical utility of AI-assisted writing activities even when aspects of scheduling, facilitation, flexibility, or feedback are perceived less favorably. This interpretation is consistent with research showing that AI-assisted writing can provide practical support for writing processes

while also creating new demands related to evaluation, critical judgment, and responsible use (Ros & Samuel, 2025; Sanz-Tejeda et al., 2026).

This interpretation is consistent with the broader literature indicating that AI-supported learning can provide practical support while simultaneously introducing new requirements for users. Recent research on AI-supported writing has examined the relationship between AI tools, motivation, emotional regulation, and academic writing, suggesting that the educational value of AI extends beyond technical assistance alone.

For teacher professional development, the implication is that the perceived usefulness of an AI tool and the perceived quality of the training process should be treated as related but distinct dimensions. A training program can therefore be experienced as useful because participants gain access to tools or techniques while still leaving room for improvement in facilitation and organization. This distinction is supported by recent studies showing that meaningful teacher use of AI depends on readiness, institutional support, professional-development needs, and fit with teachers' actual work rather than exposure to tools alone (Cheah et al., 2025; Chen et al., 2025; Hazzan-Bishara et al., 2025; Moorhouse, 2024). Research on GenAI-supported professional development likewise emphasizes the importance of guided learning and contextualized support (Lakhe Shrestha et al., 2025; Zhang & Wang, 2025).

The Unexpected Negative Association between Training Management and Perceived Effectiveness

The most striking finding is the moderate negative correlation between training management and perceived training effectiveness ($r = -0.44$). This result requires particularly cautious interpretation. It would be inappropriate to conclude that better training management causes lower effectiveness. The study employed a cross-sectional correlational design, and the analysis does not establish temporal ordering or causality. Instead, the result indicates that, within this group of participants, more favorable perceptions of training management tended to coincide with less favorable perceptions of training effectiveness.

One possible explanation is a mismatch between standardized training structures and participants' individual learning needs. Such a possibility is compatible with learner-centred perspectives on GenAI-supported learning, which emphasize autonomy, learner voice, criticality, and self-determined learning rather than purely standardized instructional structures (Narayan & Vanderburg, 2025). The training management construct includes clarity of objectives, organization, facilitation, flexibility, and evaluation. A highly structured training process may provide direction, but structure alone does not guarantee that

participants can adapt the learning process to their different levels of digital readiness, writing experience, and professional needs.

This interpretation is particularly relevant to AI-assisted professional learning. Unlike a conventional technical training program in which participants may simply follow a predetermined sequence of operations, AI-assisted writing involves experimentation, iterative prompting, evaluation of generated content, revision, and human judgment. Participants may therefore require both guidance and room for adaptation.

The finding can also be interpreted alongside the concept of heutagogy. Narayan and Vanderburg (2025) argue that learning in the generative-AI era should be more learner-centred and self-determined, emphasizing partnership, criticality, authenticity, and learner voice. Thus, the negative association observed in this study may indicate not that structure is inherently problematic, but that the form of structure matters. Structure that guides participants without constraining their learning choices may be more appropriate than rigid standardization.

This distinction is important because the original manuscript interprets the result as evidence that "overly rigid" training management may reduce teachers' motivation and confidence. The available data, however, do not directly measure rigidity, motivation, or confidence as separate constructs. Therefore, the more defensible interpretation is that the negative association raises the possibility of a mismatch between training organization and participants' learning needs, rather than demonstrating a causal effect of rigidity.

AI Integration Does Not Automatically Produce Higher Perceived Effectiveness

The weak negative association between AI technology integration and perceived training effectiveness ($r = -0.22$) provides a second important insight. At first glance, this finding may appear counterintuitive. If participants perceive greater integration of AI tools, one might expect them to evaluate the training as more effective. The data does not support such a straightforward relationship.

A plausible explanation is that technology integration creates additional learning demands. The presence of AI tools does not eliminate the need for participants to understand how to formulate prompts, evaluate generated content, verify information, revise outputs, and incorporate AI assistance appropriately into academic writing (Ahmed, 2025). Similar concerns have emerged in higher education, where teachers have identified both opportunities and challenges associated with AI use and anticipated changes in assessment practices (Karunaratne & Lindblad, 2025). This interpretation is supported by the broader literature showing that AI-supported writing requires users to engage critically with generated content rather than treating automated output as inherently reliable or authoritative (Abubakar et al., 2025; Ros & Samuel, 2025). Consequently, technology can

simultaneously provide support and introduce cognitive and procedural demands. This dual role is also reflected in research on AI writing tools and AI-generated feedback, where technological support can enhance aspects of writing while requiring teachers and learners to remain actively involved in evaluating and shaping the final text (Marzuki et al., 2023; Youn & Salam, 2025).

This interpretation is consistent with research on AI adoption among Indonesian teachers. Teacher readiness has also been identified as an important condition for effective AI adoption, particularly in relation to technological readiness and pedagogical preparedness (Zaki & Ulya, 2025). Harsanti et al. (2025), for example, found that teachers' intention to use AI is related to digital readiness and perceived usefulness, while training, support, and resource access influence the broader adoption process.

The implication is that AI integration should not be evaluated simply by the number or availability of tools used during training. What matters is whether participants are able to use those tools meaningfully within their professional tasks. In scientific writing training, this means moving beyond tool demonstrations toward guided practice, critical evaluation, revision, and application to authentic writing tasks.

Training Management and AI Integration Are Positively Associated

In contrast to the two relationships discussed above, training management and AI technology integration demonstrated a moderate positive correlation ($r = 0.37$). This finding indicates that participants who evaluated the management of the training more favorably also tended to report more favorable perceptions of AI integration. This relationship is substantively plausible: clear objectives, organized activities, facilitation, and feedback can help participants navigate unfamiliar technologies.

The result is particularly relevant because AI adoption among teachers is not simply a matter of individual willingness. Recent evidence from Indonesian school teachers highlights the importance of digital readiness and perceived usefulness in shaping AI adoption. Training therefore has a potentially important role in creating conditions through which teachers can understand and experiment with AI. This interpretation is consistent with recent evidence that professional development, clear guidance, technical support, and teacher competence shape whether GenAI is integrated meaningfully in educational practice (Huynh et al., 2025; Ng et al., 2025; Somabut et al., 2025).

However, the positive relationship between management and AI integration should not be interpreted as evidence that better management automatically improves training effectiveness. Taken together with the negative management-effectiveness association, the findings suggest a more complex pattern: training management appears to be associated

with AI integration, but AI integration itself is not positively associated with perceived effectiveness in this sample.

This is perhaps the most important contribution of the study. It challenges a simple linear assumption: better management, more AI integration, and better effective training. Related studies also show that AI-focused learning experiences can influence teachers' and pre-service teachers' attitudes, anxiety, competence, feedback practices, and practical use of AI, reinforcing the importance of how the training is designed rather than the mere presence of AI tools (Kinder et al., 2025; Nurmasitah et al., 2025; Sat, 2025; Widhiyanto et al., 2025).

Toward a More Context-Responsive Model of AI-Assisted Teacher Development

Taken together, the three correlations point toward a more nuanced understanding of AI-assisted teacher professional development. The findings indicate that: (1) Training management is positively associated with AI integration; (2) Training management is negatively associated with perceived effectiveness; (3) AI integration is weakly negatively associated with perceived effectiveness.

These results should not be interpreted as evidence that management or AI integration is inherently detrimental. Rather, they suggest that the relationship between training organization, technology use, and perceived effectiveness is context-dependent and potentially non-linear.

The context of Tapanuli Utara is relevant here. This contextual consideration is consistent with evidence from Indonesia showing that teachers' AI adoption is shaped not only by the availability of AI technologies but also by digital readiness, perceived usefulness, and the broader support environment (Harsanti et al., 2025). The study was conducted among teachers in an environment where digital infrastructure and internet access were described as variable. Such conditions can influence how teachers experience AI-assisted learning. A training structure that is appropriate in a highly connected environment may not necessarily produce the same experience in a setting where technological access, prior digital experience, and opportunities for independent experimentation differ. This concern is consistent with Indonesian teacher-training evidence emphasizing the need for sustained and mentor-supported AI training (Fauziah et al., 2024).

Recent research on Indonesian teachers likewise demonstrates that AI adoption is connected to digital readiness and perceived usefulness rather than technological availability alone. This reinforces the importance of treating AI professional development as a capacity-building process, rather than simply a technology implementation exercise.

Accordingly, a more appropriate model of AI-assisted scientific writing training would combine structured guidance, flexibility, authentic writing tasks, iterative feedback, and

opportunities for participant autonomy. Such an approach would preserve the benefits of organized training while allowing teachers to adapt AI tools to their own professional needs.

CONCLUSIONS

This study examined AI-assisted scientific writing training among 30 junior secondary school teachers in Tapanuli Utara, Indonesia, focusing on training management, AI technology integration, and perceived training effectiveness. The findings showed that perceived training effectiveness received the highest mean score (M = 4.01), followed by AI technology integration (M = 3.88) and training management (M = 3.57).

The correlation analysis revealed a moderate positive association between training management and AI technology integration (r = 0.37), a moderate negative association between training management and perceived training effectiveness (r = −0.44), and a weak negative association between AI technology integration and perceived training effectiveness (r = −0.22).

These findings suggest that the effectiveness of AI-assisted scientific writing training cannot be understood solely in terms of the quality of training management or the extent of technology integration. Rather, the way training is structured, facilitated, and adapted to participants' needs appears to be an important contextual consideration. The negative correlations should not be interpreted causally; instead, they highlight the need to reconsider assumptions that more structured management or greater technology integration will automatically produce more effective professional learning.

For teacher professional development, the central implication is therefore not to reduce structure or technology use, but to reconfigure them. AI-assisted training should provide sufficient structure to guide participants while maintaining flexibility for experimentation, individualized support, and authentic professional application. Such an approach may be particularly relevant in contexts where teachers' digital readiness and access to technological resources vary

Future studies should involve larger multi-school samples, report participant demographics and school characteristics, and examine the psychometric properties of the measurement instruments. Longitudinal or experimental studies could also combine perception measures with direct assessments of scientific-writing performance to determine whether flexible, context-responsive AI training produces sustained professional learning outcomes.

DECLARATIONS

Author Contribution

Sihombing, H.B.M., Conceptualization, Methodology, Investigation, Formal Analysis, Data Curation, Writing – Original Draft, Writing – Review & Editing,

Visualization, and Project Administration; **Seli, F.Y**., Methodology, Investigation, Data Curation, Formal Analysis, and Writing – Review & Editing; **Pantas, P.E.,** Validation, Supervision, Writing – Review & Editing, and Project Administration.

All authors contributed to the interpretation of the findings, critically reviewed the manuscript for important intellectual content, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

Funding Statement

This research was supported by the Directorate General of Higher Education, Science and Technology, Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, through the Reputable Journal Publication Assistance Program. The authors gratefully acknowledge this support.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of AI Use

Generative AI tools were used during the preparation of this manuscript for language improvement, academic writing refinement, structural organization, and editorial assistance. ChatGPT (OpenAI) was used under the authors' supervision to improve language clarity, refine the organization and academic presentation of the manuscript, and assist in editing selected sections. The authors independently reviewed and verified the content, interpretation of the research findings, citations, and final manuscript. The authors remain fully responsible for the accuracy, originality, interpretation, and conclusions presented in this article.

Additional Information

Ethical Approval: All participants provided informed consent to participate in the study and to the use of the data collected for research purposes. The study also obtained official permission from the Government of Tapanuli Utara through the local Education Office in accordance with applicable research procedures.

Data Availability: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request, subject to applicable ethical and institutional restrictions.

Acknowledgments: The authors would like to express their sincere gratitude to the participating junior secondary school teachers in Tapanuli Utara for their valuable participation and contributions to this study.

REFERENCE

Abubakar, S., Jeilani, A., & Yusuf, M. (2025). The role of over-reliance on AI in the negative consequences of student learning: The moderating effects of ethical concerns and institutional policies. *Cogent Education, 12*(1), 2591503. https://doi.org/10.1080/2331186X.2025.2591503

Ahmed, S. A. (2025). Learning, meaning, and teaching in the age of AI: Communication development checkpoints. *Frontiers in Education, 10*, 1720706. https://doi.org/10.3389/feduc.2025.1720706

Chandra, P. S., Permadi, A. L., Hastuti, W. P., Sufi, W., Siahaan, M., Akbar, D. F., & Fauzi, A. (2025). Pelatihan pembuatan modul pelajaran untuk guru SLB dengan artificial intelligence (AI): Transformasi kompetensi pendidik khusus di era digital. *Development: Journal of Community Engagement, 4*(4), 657–668. https://doi.org/10.46773/djce.v4i4.2831

Cheah, Y. H., Lu, J., & Kim, J. (2025). Integrating generative artificial intelligence in K-12 education: Examining teachers' preparedness, practices, and barriers. *Computers and Education: Artificial Intelligence, 8*, 100363. https://doi.org/10.1016/j.caeai.2025.100363

Chen, R., Lee, V. R., & Lee, M. G. (2025). A cross-sectional look at teacher reactions, worries, and professional development needs related to generative AI in an urban school district. *Education and Information Technologies, 30*, 16045–16082. https://doi.org/10.1007/s10639-025-13350-w

Fauziah, A. N. M., Widodo, W., Hidayati, S. N., Aulia, E. V., Sari, D. P., & Zahro, F. (2024). Optimalisasi Kurikulum Merdeka melalui pelatihan guru untuk mengimplementasikan teknologi AI dalam pengembangan media pembelajaran. *Sasambo: Jurnal Abdimas (Journal of Community Service), 6*(4), 702–714. https://doi.org/10.36312/sasambo.v6i4.2206

Harsanti, H. R., Sudibjo, N., Riady, S., & Yu, P. (2025). Exploring Indonesian teachers' intention to use artificial intelligence in schools: The impact of digital leadership, digital readiness, and perceived usefulness. *Cogent Social Sciences, 11*(1), 2593596. https://doi.org/10.1080/23311886.2025.2593596

Hazzan-Bishara, A., Kol, O., & Levy, S. (2025). The factors affecting teachers' adoption of AI technologies: A unified model of external and internal determinants. *Education and Information Technologies, 30*, 15043–15069. https://doi.org/10.1007/s10639-025-13393-z

Huynh, L., Le, T. H., Dang, B., An, B. T., Vu, C. T., & Nguyen, A. (2025). Mindset matters: Fostering teachers' responsible AI use through professional development. *Journal of New Approaches in Educational Research, 14*, 23. https://doi.org/10.1007/s44322-025-00043-y

Karunaratne, T., & Lindblad, E. (2025). Imagining assessment futures through artificial intelligence in higher education: Teachers' perspectives. *Discover Education, 4*, 532. https://doi.org/10.1007/s44217-025-00987-5

Kinder, A., Briese, F. J., Jacobs, M., Dern, N., Glodny, N., Jacobs, S., & Leßmann, S. (2025). Effects of adaptive feedback generated by a large language model: A case study in teacher education. *Computers and Education: Artificial Intelligence, 8*, 100349. https://doi.org/10.1016/j.caeai.2024.100349

Lakens, D. (2022). Sample size justification. *Collabra: Psychology, 8*(1), 33267. https://doi.org/10.1525/collabra.33267

Lakhe Shrestha, B. L., Dahal, N., Hasan, M. K., Paudel, S., & Kapar, H. (2025). Generative AI on professional development: A narrative inquiry using TPACK framework. Frontiers in Education, 10, 1550773. https://doi.org/10.3389/feduc.2025.1550773

Marzuki, M., Widiati, U., Rusdin, D., Darwin, & Indrawati, I. (2023). The impact of AI writing tools on the content and organization of students' writing: EFL teachers' perspective. *Cogent Education, 10*(2), 2236469. https://doi.org/10.1080/2331186X.2023.2236469

Moorhouse, B. L. (2024). Beginning and first-year language teachers' readiness for the generative AI age. *Computers and Education: Artificial Intelligence, 6*, 100201. https://doi.org/10.1016/j.caeai.2024.100201

Narayan, V., & Vanderburg, R. (2025). Heutagogy and Gen AI: A conversation. *Pacific Journal of Technology Enhanced Learning, 7*(2), 50. https://doi.org/10.24135/pjtel.v7i2.238

Ng, D. T. K., Chan, E. K. C., & Lo, C. K. (2025). Opportunities, challenges and school strategies for integrating generative AI in education. *Computers and Education: Artificial Intelligence, 8*, 100373. https://doi.org/10.1016/j.caeai.2025.100373

Nurmasitah, S., Kusumastuti, A., Anis, S., Utomo, A. B., & Saputro, G. E. (2025). AI-assisted scientific writing training to enhance the professional competence of madrasah teachers. *Jurnal Puruhita, 7*(1), 6–10.

Ros, T. J., & Samuel, A. (2025). Artificial intelligence in academic writing: Tools and techniques for scholars to succeed in the publishing world. *New Directions for Adult and Continuing Education, 2025*(188), 57–62. https://doi.org/10.1002/ace.70014

Sanz-Tejeda, A., Domínguez-Oller, J. C., Baldaquí-Escandell, J. M., Gómez-Díaz, R., & García-Rodríguez, A. (2026). The impact of generative AI on academic reading and writing: A synthesis of recent evidence (2023–2025). *Frontiers in Education, 10*, 1711718. https://doi.org/10.3389/feduc.2025.1711718

Sat, M. (2025). The impact of AI integration in project preparation in education course on pre-service teachers' innovativeness, AI anxiety, attitudes, and acceptance. *BMC Psychology, 13*, 1297. https://doi.org/10.1186/s40359-025-03647-3

Shi, L. (2025). Assessing teachers' generative artificial intelligence competencies: Instrument development and validation. *Education and Information Technologies, 30*, 23365–23384. https://doi.org/10.1007/s10639-025-13684-5

Sims, S., & Fletcher-Wood, H. (2021). Identifying the characteristics of effective teacher professional development: A critical review. *School Effectiveness and School Improvement, 32*(1), 47–63. https://doi.org/10.1080/09243453.2020.1772841

Somabut, A., Tuamsuk, K., Lowatcharin, G., Traiyarach, S., & Kwangmuang, P. (2025). Preparing for the AI era: Science teachers' readiness and professional development needs for generative AI integration in secondary education. *Social Sciences & Humanities Open, 12*, 102259. https://doi.org/10.1016/j.ssaho.2025.102259

Wang, C., Wang, B., & Xu, D. (2025). The role of ChatGPT and Grammarly in promoting emotion regulation, psychological well-being, motivation, and academic writing in Chinese college students: A self-determination theory perspective. *Learning and Motivation, 90*, 102131. https://doi.org/10.1016/j.lmot.2025.102131

Widhiyanto, W., Prabowo, A., Hapsari, C. T., Mutiaraningrum, I., Anggraeni, C. W., Ifadah, M., & Yafi, M. A. (2025). Pelatihan guru SMA dalam menggunakan AI untuk menyusun materi, menerapkan strategi, dan melaksanakan asesmen. *Jurnal Surya Masyarakat, 8*(1), 178–189. https://doi.org/10.26714/jsm.8.1.2025.178-189

Youn, C. H., & Salam, A. R. (2025). A systematic review on the use of artificial intelligence in providing feedback in teaching writing. *LSP International Journal, 12*(2), 133–142. https://doi.org/10.11113/lspi.v12.26003

Yue, M., Jong, M. S.-Y., & Ng, D. T. K. (2024). Understanding K-12 teachers' technological pedagogical content knowledge readiness and attitudes toward artificial intelligence education. *Education and Information Technologies, 29*, 19505–19536. https://doi.org/10.1007/s10639-024-12621-2

Zaki, A. R. M., & Ulya, I. A. (2025). Analisis kesiapan pedagogis dan teknologis guru dalam mengadopsi AI sebagai sarana pembelajaran adaptif. *Jurnal Pendidikan Indonesia, 6*(7), 3692–3700. https://doi.org/10.59141/japendi.v6i7.8434

Zhang, H., & Wang, Q. (2025). How could GenAI work on in-service teachers' knowledge building process? An empirical study based on epistemic network analysis. *International Journal of Educational Technology in Higher Education, 22*, 47. https://doi.org/10.1186/s41239-025-00544-y